NWS-00316- 01.02 - 01/01/89

HELP MODEL EVALUATION
WASTE OTTO FUEL TANK SITE
BUILDING 1816
NAVAL WEAPONS STATION
YORKTOWN, VA

prepared for
ATLANTIC DIVISION, NAVAL FACILITIES ENGINEERING COMMAND
Norfolk, VA

prepared by
ENVIRONMENTAL AND SAFETY DESIGNS, INC. (EnSafe)
Memphis, TN

January 1989

EnSafe

INTRODUCTION
The US Naval Weapons Station (NAVWPNSTA) Yorktown, VA proposed to construct an addition to the existing torpedo intermediate maintenance facility (TIMA) (Building 1816). Waste Otto fuel constituents have been discovered in the soil and groundwater in the immediate vicinity of an existing underground waste Otto fuel storage tank, located between the existing building and the proposed addition. In June 1988, NAVWPNSTA Yorktown submitted a Closure Plan to the VA Department of Waste Management (DWM), proposing decontamination and excavation of the tank and an assessment and decontamination of the surrounding area.

In the "Notice of Deficiency" (NOD) related to the Closure Plan, VA DWM stated:

> "If the new building is proposed to serve as an appropriate cap, Yorktown must demonstrate the suitability of the structure for that purpose, including use of the EPA HELP model to verify equivalence to EPA approved cover."

On behalf of NAVWPNSTA Yorktown, Atlantic Division, Naval Facilities Engineering Command retained EnSafe and Dames & Moore to make that comparison, using the HELP model.

SUMMARY OF EPA HELP MODEL
The Hydrologic Evaluation of Landfill Performance (HELP) computer program is a hydrologic model of water movement across, into, through and out of landfills. The model accepts climatological, soil, and design data and utilizes a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage, and lateral drainage. Landfill cover systems including various combinations of vegetation, cover soils, waste cells, drainage layers, and relatively impermeable barrier soils, as well as synthetic membrane covers and liners, may be modeled. The program was developed to facilitate rapid estimation of the amounts of runoff, drainage and leachate that may be expected to result from the operation of a wide variety of landfill designs. The model can accept site-specific environmental and design data; however, "default" databases of regional environmental data are stored for use in the absence of detailed site-specific data.

SETTING
The map pocket at the back of this report contains a reproduction of the site plan (sheet C-3) from the construction drawings of the Building 1816 addition. That

drawing orients the site of the waste Otto fuel tank to the expanded facility. These site factors affect the application of the HELP model:

* the tank site is located within an alcove between the existing building and the addition;
* new bituminous pavement will be applied to the surface within the alcove;
* roof drainage from the addition will be collected in downspouts that are directly connected to storm sewers that convey that water off-site to a discharge channel; and
* currently, roof drainage from the existing building is discharged through downspouts onto the pavement surface surrounding the building (including the vicinity of the waste Otto fuel tank).

HELP MODEL APPLICATION

The land parcel containing the expanded TIMA is covered by two types of improvements--buildings and bituminous pavement. The asphalt pavement has properties that are input parameters to the HELP model, e.g., porosity, moisture content, hydraulic conductivity. Conversely, those properties are not relevant to the building. These elements of the building are specifically designed to prevent vertical transport of water:

* the built-up roof, which will repel rainfall, diverting it to downspouts;
* storm sewers, which collect roof drainage from the downspouts, conveying it off-site; and
* the concrete floor, which is protected by the roof and is underlain by a synthetic moisture barrier.

In sum, the design features of the building prohibit migration of rainfall into the soil immediately beneath the building floor; therefore, the building exhibits a hydraulic conductivity of zero. Therefore, that component of the parcel exceeds the protection provided by the EPA-approved cap.

Attachment I presents the comparison by Dames & Moore of the asphalt apron with the EPA-approved cap design using the EPA HELP model.

CONCLUSIONS

The Dames & Moore report in Attachment I confirms that the asphalt apron exceeds the EPA-approved cap in minimizing migration of water into the underlying soil, allowing only 0.7 percent of rainfall to infiltrate the cap, compared to 4.1 percent infiltration through an EPA-approved cap.

RECOMMENDATIONS

The Dames & Moore report presents asphalt mix design and apron construction and maintenance recommendations to ensure the protection of the underlying soil. EnSafe endorses those recommendations.

EnSafe also recommends that all downspouts on the existing building that discharge into the alcove overlying the tank site be connected to the storm sewer serving the addition, thus preventing surplus water being discharged onto the surface of the asphalt apron.

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ATTACHMENT I
HELP MODEL ANALYSIS

EnSafe

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DAMES & MOORE A PROFESSIONAL LIMITED PARTNERSHIP
644 LINN STREET, SUITE 501, CINCINNATI, OHIO 45203 (513) 651-3440

December 22, 1988

Ensafe
5705 Stage Road
Memphis, TN 38134

Attention: Dr. James N. Speakman, P.E.

Dear Dr. Speakman:

Re: Hydrologic Evaluation
Yorktown Naval Facility
Yorktown, Virginia

INTRODUCTION

This report presents a hydrologic analysis of the proposed closure of the Otto Fuel Storage tank at the Yorktown Naval Facility. The proposed closure involves removing an underground storage tank and sump, backfilling with clean soil, and covering the surface with two-inch-thick asphaltic concrete pavement. It is understood that the area of pavement serving as a cap will lie between the existing and the proposed building, and access will be restricted to foot traffic.

The Virginia Department of Waste Management (VDWM) has requested a hydrologic analysis of the proposed asphalt cap. VDWM specified that this analysis compare the asphalt cap to an EPA approved cap on the basis of suitability "to serve as an appropriate cap." VDWM requested that this analysis include use of the Hydrologic Evaluation of Landfill Performance (HELP) computer model.

HYDROLOGIC ANALYSIS

Figure 1 shows typical sections of the two caps analyzed. The EPA approved cap is based on comments by VDWM. The asphalt cap is based on engineering drawings for construction of the Torpedo Intermediate Maintenance Facililty.

The HELP model is a water balance computer model developed by the U.S. Army Corps of Engineers for the U.S. Environmental Protection Agency. It estimates the volume of water falling on a surface as rain which infiltrates the ground. The model accounts for precipitation, runoff, evaporation, transpiration, lateral drainage, and infiltration (percolation). Input and output data for the analyses are presented in Appendix A.

A review of published literature indicated that asphaltic concrete can be designed and placed to achieve a permeability of 1×10^{-7} cm/sec or less[1] . It is assumed that construction and maintenance measures will be used to prevent cracks which can dramatically increase the effective permeability of the pavement. Therefore, for the analysis of the asphalt cap, a permeability of 1×10^{-7} cm/sec was assumed.

The EPA approved cap, as described by VDWM, consists of three layers:

1. 24-inch-thick vegetative layer - assumed to be silt
2. 12-inch-thick drainage layer with a hydraulic conductivity of at least 1×10^{-3} cm/sec and a 2% slope, sandwiched between granular or synthetic filters to prevent plugging of the drainage material - assumed to be sand
3. 24-inch-thick barrier layer with a hydraulic conductivity of 1×10^{-7} cm/sec or less - assumed to be clay

The drainage length of the lateral drainage layer for the HELP model is 50 feet. This is based on the maximum width of the area of contaminated soil shown in the Contamination Assessment report by Dames & Moore dated November 4, 1988.

Comparison of the two caps is based on infiltration of surface water into the ground. Approximately 0.7 percent of precipitation is estimated to infiltrate through the asphalt cap. Estimated infiltration from the bottom of the EPA approved cap is 4.1 percent of precipitation. Thus, results of the analysis indicate that the asphalt cap would be more effective at limiting infiltration. Even though the asphalt cap would have the same permeability and less thickness than the clay barrier layer of the EPA approved cap, it

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[1] *Lining of Waste Impoundment and Disposal Facilities*, SW-870, USEPA, September, 1980, p. 49.

would be more effective at reducing infiltration because the asphalt would shed virtually all of the precipitation immediately as runoff. The EPA approved cap would absorb much of the precipitation and allow it to remain within the cap system for a longer period of time.

The HELP results show that the asphalt cap would direct 99.0 percent of average annual precipitation off the surface as runoff. The EPA approved cap would shed an estimated 3.4 percent as runoff because its grass-covered soil surface would be much rougher and absorbant than the asphalt cap. The remainder of the precipitation falling on the EPA approved cap would evaporate, transpire through vegetation, or percolate into the underlying lateral drainage layer.

The water which would percolate into the lateral drainage layer accounts for approximately 20.9 percent of average annual precipitation. This water would percolate through the sand to the barrier layer, and then be directed laterally toward the edge of the cap. However, part of the sand layer would have to become saturated and a certain amount of head would have to develop over the barrier layer to drive the lateral flow. This head would cause vertical percolation through the barrier layer of an estimated 4.1 percent.

The estimated infiltration through asphalt is very sensitive to the permeability. Increasing permeability by a factor of 10 may increase estimated infiltration by a factor of 5. Therefore, carefully controlled design, construction, and maintenance of the asphalt cap are necessary to maintain this low permeability, as described in the following recommendations.

RECOMMENDATIONS

The mix design for the asphalt cap should be similar to that for conventional pavement, but the amount of fines (material passing a #200 sieve) and asphalt cement should be increased. In order to provide a low-permeability cap, the Asphalt Institute[2] recommends that fines should comprise approximately 8-15 percent by weight of the total

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[2] *Asphalt in Hydraulics*, Manual Series No. 12, Asphalt Institute, College Park, Maryland, November, 1976, p. 15

mix; the asphalt cement content should be 6.5-9.5 percent by weight. Asphalt cement should be AC-20 grade or equivalent.

Dames & Moore recommends that the thickness of the asphalt cap be increased to 3 inches to allow for construction of the cap in two lifts. This will allow the joints between lifts of asphalt to be staggered to prevent a vertical crack at the joint from extending through the entire depth of the pavement. Three inches of pavement is required because the minimum thickness that can be constructed is 1.5 inches. HELP results from analysis of a 3-inch-thick asphalt cap show that it would perform as well as a 2-inch-thick cap (Appendix A).

The asphalt cap should be constructed much like conventional pavement. The backfill for the tank and the base course for the asphalt should be compacted in lifts to minimize settlement. A soil sterilant should be applied to prevent weed growth through the pavement. A prime coat of hot liquid asphalt should be applied to the surface of the base course and allowed to cure. The asphalt cap should be placed with a paving machine and compacted with a roller in finished lifts 1.5 inches thick. The edges of each course should be angled at no steeper than 1 horizontal to 1 vertical so that joints with subsequent courses will not have vertical cracks which can leak. In addition, these construction joints should be staggered as discussed above.

Maintenance of the asphalt cap will be necessary to prevent leaks. The surface should be inspected semiannually (Spring and Fall) and cracks should be filled or sealed with liquid asphalt. The surface should be periodically coated with liquid asphalt to rejuvenate the cap as it deteriorates from abrasion and ultra-violet radiation.

Dames & Moore has enjoyed preparing this report for Ensafe. If we can be of

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further assistance or if you have any questions, please call.

Very truly yours,

DAMES & MOORE

Randolph C. Bohachek

Randolph C. Bohachek, P.E.
Project Engineer

Fred W. Erdmann

Fred Erdmann, P.E., C.P.G.
Associate

RCB/FE/rcb

STATE OF OHIO
FRED WILLIAM
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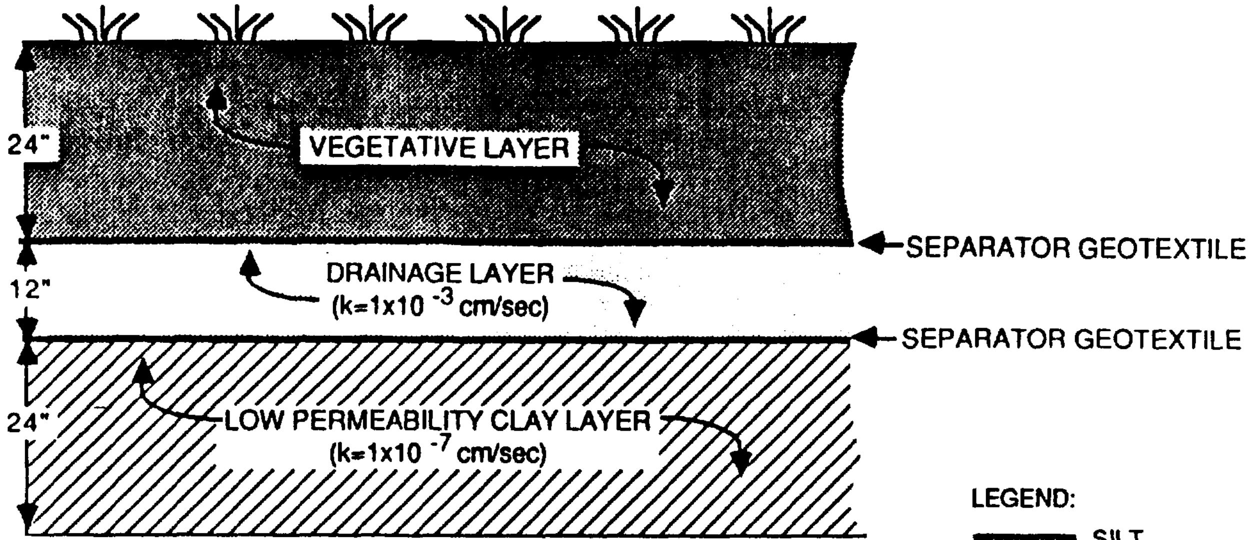
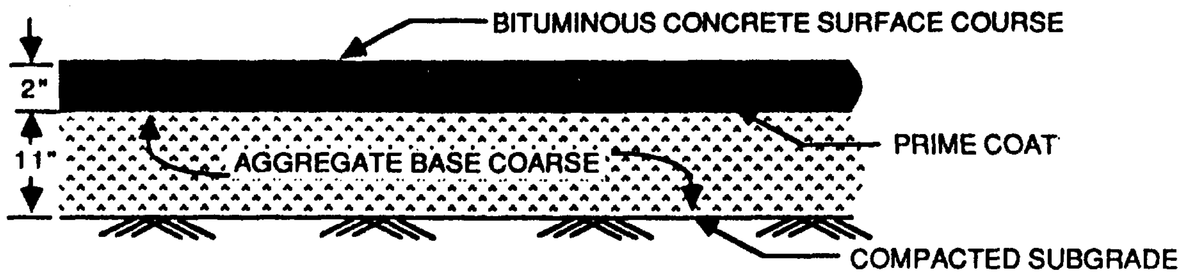


LEGEND:
SILT
SAND
CLAY

EPA APPROVED CAP

SCALE: 1"=2'



BITUMINOUS PAVEMENT CAP

NOT TO SCALE

ENSAFE YORKTOWN NAVAL FACILITY YORKTOWN, VIRGINIA	
FIGURE 1 **CAP SECTIONS**	
JOB NO. 17876-002-17	Dames & Moore

APPENDIX A

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NAVY STUDY
YORKTOWN, VIRGINIA
12/12/88

EPA APPROVED CAP

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2326 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2528 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0003700000234 CM/SEC

LAYER 2

LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4570 VOL/VOL
FIELD CAPACITY	=	0.1314 VOL/VOL
WILTING POINT	=	0.0581 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2848 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0010000000475 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	50.0 FEET

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LAYER 3

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3667 VOL/VOL
WILTING POINT	=	0.2804 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0000001000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	79.01
TOTAL AREA OF COVER	=	43560. SQ FT
EVAPORATIVE ZONE DEPTH	=	22.00 INCHES
UPPER LIMIT VEG. STORAGE	=	10.4860 INCHES
INITIAL VEG. STORAGE	=	5.6301 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR NORFOLK VIRGINIA

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	44.44	(7.257)	161317.	100.00
RUNOFF	1.510	(0.937)	5480.	3.40
EVAPOTRANSPIRATION	33.675	(2.068)	122239.	75.78
LATERAL DRAINAGE FROM LAYER 2	7.4653	(4.1236)	27099.	16.80
PERCOLATION FROM LAYER 3	1.8048	(0.2609)	6551.	4.06
CHANGE IN WATER STORAGE	-0.014	(3.099)	-52.	-0.03

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.81	13830.3
RUNOFF	1.354	4914.5
LATERAL DRAINAGE FROM LAYER 2	0.0859	312.0
PERCOLATION FROM LAYER 3	0.0085	30.7
HEAD ON LAYER 3	35.8	
SNOW WATER	1.42	5154.6

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4630
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1158

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.28	0.2616
2	3.22	0.2686
3	10.32	0.4300
SNOW WATER	0.00	

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NAVY STUDY
YORKTOWN, VIRGINIA
12/8/88

ASPHALT CAP - 2" THICK

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LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	2.00 INCHES
POROSITY	=	0.0282 VOL/VOL
FIELD CAPACITY	=	0.0250 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0210 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0000001000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	98.00
TOTAL AREA OF COVER	=	43560. SQ FT
EVAPORATIVE ZONE DEPTH	=	0.01 INCHES
UPPER LIMIT VEG. STORAGE	=	0.0003 INCHES
INITIAL VEG. STORAGE	=	0.0002 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR NORFOLK VIRGINIA

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	44.44	(7.257)	161317.	100.00
RUNOFF	44.001	(7.175)	159724.	99.01
EVAPOTRANSPIRATION	0.127	(0.094)	461.	0.29
PERCOLATION FROM LAYER 1	0.3099	(0.0236)	1125.	0.70
CHANGE IN WATER STORAGE	0.002	(0.006)	6.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.81	13830.3
RUNOFF	3.807	13819.9
PERCOLATION FROM LAYER 1	0.0031	11.4
SNOW WATER	1.42	5154.6

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.0282
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0161

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	0.05	0.0254
SNOW WATER	0.00	

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NAVY STUDY
YORKTOWN, VIRGINIA   ASPHALT CAP - 3" THICK
12/22/88

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LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	3.00 INCHES
POROSITY	=	0.0282 VOL/VOL
FIELD CAPACITY	=	0.0250 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0210 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0000001000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	98.00
TOTAL AREA OF COVER	=	43560. SQ FT
EVAPORATIVE ZONE DEPTH	=	0.01 INCHES
UPPER LIMIT VEG. STORAGE	=	0.0003 INCHES
INITIAL VEG. STORAGE	=	0.0002 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR NORFOLK VIRGINIA

NWS-00316- 01.02 - 01/01/89

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	44.44	(7.257)	161317.	100.00
RUNOFF	44.001	(7.175)	159724.	99.01
EVAPOTRANSPIRATION	0.127	(0.094)	461.	0.29
PERCOLATION FROM LAYER 1	0.3089	(0.0236)	1121.	0.70
CHANGE IN WATER STORAGE	0.003	(0.009)	10.	0.01

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.81	13830.3
RUNOFF	3.807	13819.9
PERCOLATION FROM LAYER 1	0.0031	11.3
SNOW WATER	1.42	5154.6

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.0282

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0161

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	0.08	0.0257
SNOW WATER	0.00	

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